OPTIMIZATION OF PRODUCTION PARAMETERS IN SMS PLANT, WELSPUN.

Thesis submitted in the partial fulfillment of the requirements for the award of the degree of

Master in Technology

In

Metallurgical and Materials Engineering

Submitted by

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CERTIFICATE

This is to certify that the project entitled,

"OPTIMIZATION OF PRODUCTION PARAMETERS IN SMS PLANT, WELSPUN",

submitted by SATYAVOLU SIRISH (212MM2340) for End Semester Evaluation of Master of Technology in Steel Technology, Department of Metallurgical and Materials Engineering at the National Institute of Technology, Rourkela is a bona-fide research work carried out under my supervision and guidance. To the best of my knowledge, the matter embodied is based on candidate's own work, has not been submitted to any other university / institute for the award of any degree or diploma.

Date:

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ABSTRACT:

Induction furnace route of steel making is a rather newborn method in the populace of the secondary steel industry. Experimentations are being done worldwide on this potentially dependable method to obtain steel of marginal to high qualities.

India being the 4th largest producer and 3rd largest consumer in the world also joined the race of secondary steel making; yet only few companies were brave and financed enough to experiment with the production of their demands through the Induction furnace method. Welspun Steel, as such, has two 40T induction furnaces, amongst the very few 40Ts in India. Purchased and serviced from the leaders in the field of customized furnace establishers, Electro-therm and Inducto-therm, Welspun is churning out the possibilities and advantages of both the leaders, maximizing its production.

Welspun Steel Limited produces steel billets of various dimensions 30% of which are sent to produce Re-bars. WSL's TMT is presently the second best TMT available for business and industry based constructions in the market after JINDAL's.

As per the Welspun Fellowship Program, the student has undergone a training period alongside doing the project in optimizing the production of the WSL plant in Anjar, Gujarat. The thesis details the findings and discusses the current issues that a typical secondary steel industry, namely WSL, is facing along with some theoretical suggestions.

DRI + Scrap is the raw material in the secondary steel production in WSL. A conclusive study is conducted to check the tap times, just by melting DRI without the steel scrap. The results indicate a success and so a new method, posing a new set of problems though, to be experimented and researched on.

Finally, sets of loopholes, neglected zones and bottlenecks have been identified all through the process of steel making and casting. Suggestions have been insisted and some of them were effectively implemented.

CONTENTS

1. INTRODUCTION

Why Steel?

The importance of steel in the modern lifestyle is too naïve to discuss. Steel is stronger and customizable than iron. The Industrial revolutions I and II show us the proofs of steel being the most important material used for tools, railroad, structures, weaponry, transportation and machines.

What is India's position and estimation of the steel future?

The present World Steel Production is 1527 MTpY and the Indian Steel Production is 72 MTpY making it the 4^{th} largest producer of steel in the world. India is also the 3^{rd} largest consumer and to meet its requirements the projected Capacity is 150MTpY, 200MTpY and 500MTpY by 2016-17, 2019-20 and 2030 respectively. Indian Steel Production is bound to grow manifold in years to come to sustain Growth in infrastructure /Construction, Automotive, Capital Goods and Consumer Durable Sector i.e. economic growth.

Indian Iron & Steel Industry is highly fragmented with a variety of process routes and thousands of small & medium units for iron & steel making and also downstream processing. Recent advances in the industry made it much more easy for the production and rapid too.

Why is alternate steel making a serious consideration more than an alternate route?

Governments, all over the world, are supporting the steel revolution of Secondary steel making, basically due to the following reasons.

- With the increase in production, energy consumption and GHG emissions will also increase correspondingly adding to Global Warming: an issue of international criticism.
- Iron & Steel making is resource intensive and Energy Intensive and have environmental Ramifications. Globally 18% of CO_2 /tcs is emitted. India 2.5-3 T/tcs Global CO_2 emission is around 30 billion tonnes /year.
- There is ambitious target to cut CO_2 emission by 50% by 2050, which is not possible adopting conventional technologies and would require Breakthrough Technologies.
- Advanced steel plants in the world already operate close to theoretical limits of mitigation strategies.
- The Specific Energy Consumption (SEC) in Indian Steel Plants have declined substantially from 10 Gcal/MT in 1990 to 6-6.5 Gcal/MT in 2009 and are still declining. Best available technologies indicate SEC of around 4.5-5 Gcal/MT for BF-BOF route and 4 Gcal/tcs for gas based DRI-EAF unit. Integrated steel plants in India are 50% more energy intensive than global average. The same holds good for CO_2 emission also.
- Still, there remains large scope for improvement of energy intensity & reduction of CO_2 emission even without pursuing breakthrough technologies.

What are the current alternative steel making practices?

The growing requirements for the material, the coal crisis, the economic considerations, and the environmental effects of the conventional steel making processes have forced the technology to turn its objective to more non-conventional practices of steel making which take lesser time, energy and have a considerable decrement in the environmental effects.

In this process lots of methods, essentially for various steel compositions are born. The most important, at a shallow depth of explanation are as follows.

FASTIRON/FASTOx – Cold briquetting is followed by the natural gas based DRI. FASTIRON is a liquid hot metal, produced by FASTMET RHF direct reduction technology, with the help of a furnace working on electric arc, and then the hot metal is charged into the conventional BOF.

DRI/EAF – After DR pelletizing, either the Cold-DRI or the Hot-DRI is entertained, the latter at about 700°C, then to the EAF at ratios of 1:1 or 7:3 of Steel scrap to DRI, along with about 22 Nm^3/t of O_2.
The product changes to a Hi-C steel if the DR is performed at 4% C instead of 2.5%.

HBI/EAF – The pelletizing is carried out and the DR is NG based, at 1.5% C. Then the EAF is engaged to produce steel at about 1620°C at about 20 Nm^3/t of O_2 and 1:1 and 7:3 scrap to DRI ratios to get a low C Steel.

FASTIRON/EAF – The FASTIRON process, with an addition of EIF processing as an intermediate step, just after DR. This reduces the slag components being forwarded to EAF.

FASTEEL – This is essentially FASTIRON/EAF with Scrap Preheat around 600°C.

HI smelt-EAF – The iron ore fines are charged into the melting furnace equipped with 30% O2 enriched hot blast. The product is HIS HM, with 4% C and 0.2% Si. The products are charged into EAF, in the popular ratios of scrap to ore and 25 to 35 Nm^3/t of O_2.

COREX – Oil fuelled pelletizing produces the raw material for acid BF, which are smelted in the smelting furnace. Then the EAF is engaged with charge ratios 1:1 or 7:3, scrap to pellets with around 45 Nm^3/t O_2 for the equal-ratio charge and around 30 Nm^3/t for the scrap-based steel.

PP – This is the normal EAF process except the concept of PP, Pig Pellets. The coal and iron ore are pelletized or briquetted in cold conditions. After feeding the pellets into a rotary furnace, the gangue is separated from the iron using custom methods, resulting in the production of iron nuggets (PP) of pig iron quality, having a carbon potential of 3 to 4 %.

These are some of the several processes of alternative steel making, which are in play, and several are about to enter the commercial market emphasizing on the concept of green steel making.

What is the importance of Induction furnace route of steel making?

Induction furnace is being used lately as an intermediate step in many steel-making processes. But, very few plants in India, mostly subsidiaries, started using the Induction furnace for direct production of steel, as DRI/EAF process, just replacing the EAF with EIF. The resulting is a faster production at the expense of quality, though to a smaller extent.

Steel making by the method of Induction using electrically energized furnaces is slowly catching up. Starting from 5 ton all the way through 10, 20, 30, 40, 50, 60 and 80T capacity furnaces can be used in steel making. But Indian equipment mostly has a maximum of 50T and 5-6 40T furnaces.

Considering the SMS (steel melt shop) in Welspun Steel Limited, the company is using a couple 40T furnaces to do the job. The molten metal from furnaces is routed through the tundish of a state-of-the art continuous caster by ladles. The casting of the molten metal into billets is done at a remarkable speed of up to 6m/min. The billets are shipped about 70-80% of the production, while the rest are dispatched to the TMT rolling mill where rolled TMT bars are shaped out of these billets.

2. THE LITERATURE REVIEW

2.1. THE PLANT:

The basic sub plants of WSL:

- DRI plant with 4 rotary kilns and a total production of about 400TPD {ton(s) per day}.
- SMS plant with a couple Induction Furnaces with a total production of 800 TPD {40 metric ton x 2}.
- Rolling mill with a total production of 200 TPD.
- Integrated Power Plant with a power generation capacity of 12MW.

2.1.1. DRI – Direct Reduced Iron

- The solid-state reduction of iron without melting.
- DRI process is carried out in rotary kilns/furnaces, 42mts in length and 2.5% in taper.
- The rotation is maintained at 0.75 rpm.
- The raw material that are fed into each rotating furnaces are:
  - Iron – pellet form.
  - Dolomite – To reduce the brimstone content in the coal.
  - Coal.
  - Coarse and Intermediate coal from the tail end of the furnace so that sufficient fuel supply is maintained.
- The flue gases, N, CO_2, CO like gases leave the rotary kiln.
- The kiln is virtually split into 7 zones based on temperatures of operation and proceeding of the chemical operation.
- Temperatures start from 790°C through 1200°C. CO is converted into CO_2, with pressurized oxygen. Thusly sending the flue gases to the power plant's WHRB-waste heat recovery boiler, where the heat of the flue gases is used to boil water into steam, which in turn is used to produce electricity.
- The oxide in the iron ore gets reacted with the CO which is the reducing gas, at temperatures < 1150°C.
- This leaves the iron pellets with pores and they look like sponge. Hence the output is called Sponge iron.
- The control room engineers monitor the several parameters of the process like, Kiln Inlet Pressure (KIP – 0.5 milli-bar), quick response temperature, temperatures at various regions of the kiln etc.

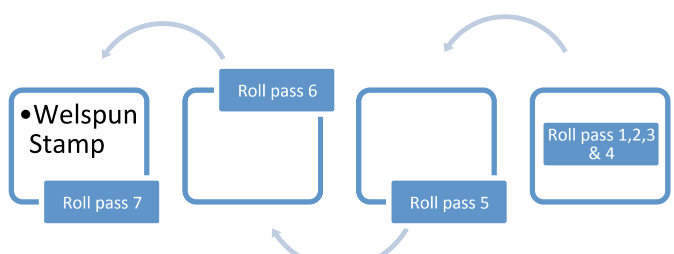
- Recommendations
  - Cleanliness – Measures for a cleaner plant can be reviewed.
  - The plant is automated but hardly maintained; temporary solutions are being practiced, rather than long-lasting solutions.

2.1.2. SMS – Steel Melt Shop

- With the furnaces A & B, electro-thermal and inducto-thermal respectively, old and newly built respectively, the SMS plant has a total production capacity of 40+40 mTPD.
- The 800t of steel per day is let out from the continuous caster at rates varying from 1.5 meter per min through 6.5 meter per min.
- The billets are cut at lengths of requirement, by skilled workmen by flamed cutters. Then the billets reach the stacker zone where they are robotically handled and air cooled as they proceed towards dispatch or storage.
- The raw materials are:
    - HMS- high metal scrap (high carbon content, mostly castables)
    - Pig iron (Jindal Steel, Mandra)
    - Scrap bundles.
    - Shredded High Carbon metal scrap
    - Continuous and discontinuous chips from mechanical operations from the pipe plant and other plants.
    - The pellets of sponge iron from DRI
    - Aluminum – to kill the steel.
    - C, Si, Mn additions – alloy additions.
- 5 Point attention policy dedicates the attention to
    - Scrap mix – for composition
    - Power – for induction furnace
    - Heat time
    - Heat size
    - Alloy Recovery
- The hot metal is poured into the ladles into which inert gas – argon is purged to stir the hot metal.

2.1.3. Rolling mill:

- A cross-country, semi-automatic rolling mill.
- This is the roughing section of the three-part mill. The initial deformation of the billet from 10mmx10mmx1.55mt to the corresponding long circular TMT bar with Welspun stamp is done here.
- This part of the plant is semi-automated and a lot of skilled manpower is essential for the effective running of the plant.
- The second part of the Rolling mill is the Intermediate mill.



- Only particular sizes of the product will use up this facility.

- The size if the billet largely reduces across cross-section and the length increases owing to the volumetric equivalency.

- The mechanism and the arrangement is largely like the roughing mill and the only noticeable difference is the roll gap is low as compared to the roughing mill.

- If the diameters of the TMT bars are needed to be bigger, then they are directly fed into the third part of the facility which is the Finishing mill.

- The rollers in these mills do not reduce the area of cross-section much, but finish them to a smoother finish and cool the temperatures from red hot to noticeable grayish steel.

- The wash beds use air-cooled water as coolants at about 94.5-96 m^3/hr.

- The long collecting and dispatching bed bears manual labor who transfer the rolled TMT bar from the guide-way to the stock. The billets that are used to produce the TMT (thermo mechanically treated re-bars) bars, are obtained from SMS – steel melt shop, from either of the two furnaces (A or B), 10mm x 10mm x (7~10) meters and they are cut into lengths 1.55mt or so according to requirement.

- They are coded according to the ISI standards B15 1786.

    - Yellow – Fe 500

    - Orange – Fe 415

    - White – Fe 500D

- The billets are heated in a furnace with a gasifier attached to it, which supplies producer gas, as the fuel.
- The three zones are
    - Pre-heating – 750 ~ 800°C
    - Heating – 800 ~ 950°C
    - Soaking – 1050~1150°C
- The furnace is equipped with a push bed operated by a couple of operators on signal basis with the help of electric bells as codes.

The features:

- The plant is integrated. The flue gases from DRI are reheated and used in the power plant, the electricity generated from which is used for the plant itself.

- The plant is spacious owing to a quick escape of the manpower at the time of any discrepancy with the heavy equipment.

- The plant is distant from normal habitat, owing to safe industrial practice.

- Being integrated, less effect on the environment.

2.2. CURRENT SCENARIO AND EXPERIMENTATION:

2.2.1. DRI PRODUCTION, CARBON-BASED:

Welspun produces an alternative source for iron, as a raw material to steel sector, by heating iron ore (hematite), consisting of 65-70% iron in it. The temperatures of the procedure are high enough to burn of the carbon and oxygen in the ore, but they will be below the melting point of iron. This is carried out in rotary kilns, and the output is pellets of directly reduced iron. Mainly the heat providers in DRI methods are natural gas, hydrogen, carbon etc. Welspun uses carbon-based reduction.

This iron is also called sponge iron, because of the porosity of the product pellets, briquettes or lumps.

During the reduction process in the production of direct reduced iron, coal is pulverized and injected along with the charge and also pressured from the tail end of the rotary kiln. This is to facilitate the reactions in the last-thirds of the kiln where the shortage of initial coal is generally evident. The result is a type of iron that is 90-97% pure, containing only minuscule amounts of carbon and other impurities.

The prominent reactions are:

$$Fe_2O_3 + C = Fe_3O_4 + CO$$

$$Fe_3O_4 + C = FeO + CO$$

$$FeO + C = Fe + CO$$

The CO coming out as a by-product from the kiln is then forced into chambers, where oxygen is forced to mix with CO to make it CO2. The gas will have a lot of latent thermal energy. Hence, it’s forwarded to the integrated power plant of Welspun in insulated overhead pipes, which run along the plant to the other side of the Welspun facility.

DRI was the most prevalent form of iron production throughout Europe and the Middle East until the 16th century. The introduction of the blast furnace helped revolutionize the iron manufacturing process and soon became the standard for production. As demand for iron increased, the blast furnace made it possible to produce large amounts of iron in a relatively short period of time. The type of iron made by blast furnaces, however, is not direct-reduced iron but pig iron, which isn't as rich as direct-reduced iron.

2.2.2. INDUCTION FURNACE:

2.2.2.1. Scenario and Procedure:

Melting process can be categorized into two different processes depending upon the condition of the furnace. These are namely:

I. Sintering process – When fresh lining has been done in the furnace either through full lining or side lining then in that case the melting that is carried out is known as sintering and the heat that is produced is known as sintering heat.
II. Regular process – When the furnace is in running condition i.e. at least 1 heat has been tapped from the furnace, then in that case the melting that is carried out is known as regular process and the heat that is produced is known as running heat.

Depending upon the type of preheating used for the furnace, sintering process/sintering cycle in the ET furnace can be divided into three broad categories:

I. If heater has been used for preheating the furnace prior to charging, then in that case the heat cycle should not be more than 4 hours at 14MW power.
II. If burner has been used for preheating after clean and dense scrap has been filled up to the former, then in that case the heat cycle should not be more than 4 hours at 14MW power.
III. If neither heater nor burner has been used for preheating the furnace, then in that case the heat should not be more than 5 hours 30 minutes at 14MW power.

Preheating the furnace, using heater is a RECOMMENDED PROCESS. However, whenever the heater breaks down, burner shall be used for preheating the furnace. If both heater and burner are not used for sintering due to lack of time, the furnace shall be operated directly, under the orders of the shift in-charge.

2.2.2.1.1.1. Sintering cycle (Heater available for preheating):

All the supporting structure for maintaining former shape and stability are removed. After getting clearance from Electrical/Mechanical dept. regarding control supply and pumps, CONTROL buttons are checked, and switched ON. The reset button is pressed to get a ready signal on the HMI provided at the furnace pulpit. Once getting a green signal, the HEAT ON button is operated, to start the furnace.

The sequence of power pick up based on optimum utilization of power is mentioned below.

NOTE: The condition may vary depending upon the condition of raw material used and/or of the lining.

1. 00:00/00:00 to 00:10/00:15 = 0MW power
2. 00:10/00:15 to 00:20/00:25 = 1MW power
3. 00:20/00:25 to 00:30/00:35 = 2.5-3MW power
4. 2nd converter should be opened. Operational power 3-6MW
5. 00:30/00:35 to 00:40/00:45 = 4MW power
6. 00:40/00:45 to 00:50/00:55 = 5MW power
7. 01:00/01:05 to 01:10/01:15 = 6MW power
8. 3rd converter should be opened. Operational power 6-10MW
9. 01:10/01:15 to 01:20/01:25 = 7.5MW power
10. 01:20/01:25 to 01:30/01:35 = 9MW power
11. 01:30/01:35 to 01:35/01:40 = 10MW power
12. 4th converter should be opened. Operational power 10-14MW
13. 01:35/01:40 to 01:45/01:50 = 12MW power
14. 01:45/01:50 to 01:55/02:00 = 14MW power
15. 01:55/02:00 to heat tap = 14MW power

2.2.2.1.1.2. Sintering cycle (Burner available for preheating):

All supporting structure for maintaining former shape and stability are removed prior to the fill-up of the former with clean and dense scrap. The burner is run for the next 2-3 hours. After getting clearance from Electrical/Mechanical dept. regarding control supply and pumps, the CONTROL button is switched ON. The reset button is pressed to get a ready signal on the HMI provided at the furnace pulpit. On getting a clearance signal, the HEAT ON button is engaged to start the furnace.

The sequence of power pick up based on optimum utilization of power is mentioned below. However the condition may vary depending upon the condition of raw material used and/or of the lining.

1. 00:00/00:00 to 00:20/00:25 = 0MW power
2. 00:20/00:25 to 00:30/00:35 = 0.5MW power
3. 00:30/00:35 to 00:40/00:45 = 1MW power
4. 00:40/00:45 to 00:50/00:55 = 1.5MW power
5. 00:50/00:55 to 01:00/01:05 = 2.5-3MW power
6. 2nd converter should be opened. Operational power 3-6MW
7. 01:00/01:05 to 00:10/00:15 = 4MW power
8. 01:10/01:15 to 01:20/01:25 = 5MW power
9. 01:20/01:25 to 01:30/01:35 = 6MW power
10. 3rd converter should be opened. Operational power 6-10MW
11. 01:30/01:35 to 01:40/01:45 = 7.5MW power
12. 01:40/01:45 to 01:50/01:55 = 9MW power
13. 01:50/01:55 to 02:00/02:05 = 10MW power
14. 4th converter should be opened. Operational power 10-14MW
15. 02:00/02:05 to 02:10/02:15 = 12MW power
16. 02:10/02:15 to 02:20/02:25 = 14MW power
17. 02:20/02:25 to heat tap = 14MW power

2.2.2.1.1.3. Sintering cycle (Neither Heater nor Burner available for preheating):

All supporting structure for maintaining former shape and stability are removed prior to the fill-up of the former with clean and dense scrap. The burner is run for the next 2-3 hours. After getting clearance from Electrical/Mechanical dept. regarding control supply and pumps, the CONTROL button is switched ON. The reset button is pressed to get a ready signal on the HMI provided at the furnace pulpit. On getting a clearance signal, the HEAT ON button is engaged to start the furnace.

The sequence of power pick up based on optimum utilization of power is mentioned below. However the condition may vary depending upon the condition of raw material used and/or of the lining.

1. 00:00/00:00 to 00:40/00:45 = 0MW power
2. 00:40/00:45 to 00:50/00:55 = 0.5MW power
3. 00:00/00:00 to 00:40/00:45 = 0MW power
4. 00:40/00:45 to 00:50/00:55 = 0.5MW power
5. 00:50/00:55 to 01:00/01:05 = 1MW power
6. 01:00/01:05 to 01:10/01:15 = 1.5MW power
7. 01:10/01:15 to 01:20/01:25 = 2MW power
8. 01:20/01:25 to 01:30/01:35 = 2.5-3MW power
9. 2nd converter should be opened. Operational power 3-6MW
10. 01:30/01:35 to 01:40/01:45 = 4MW power
11. 01:40/01:45 to 01:50/01:55 = 5MW power
12. 01:50/01:55 to 02:00/02:05 = 6MW power
13. 3rd converter should be opened. Operational power 6-10MW
14. 02:00/02:05 to 02:10/02:15 = 7.5MW power
15. 02:10/02:15 to 02:20/02:25 = 9MW power
16. 02:20/02:25 to 02:30/02:35 = 10MW power
17. 4th converter should be opened. Operational power 10-14MW
18. 02:30/02:35 to 02:40/02:45 = 12MW power
19. 02:40/02:45 to 02:50/02:55 = 14MW power
20. 02:50/02:55 to heat tap = 14MW power

2.2.2.1.1.4. Sintering Process at IT Furnace:

IT furnace has been provided with a separate set of sintering panel, which can run in parallel with the regular panel. Maximum power that can be applied through the sintering panel is 1MW. Optimum running of sintering panel for complete preheating of the furnace should be at least 4 hours at 300-400kW. However depending upon the time available, preheating time may vary. Now, depending upon the type of preheating used for the furnace, sintering process/sintering cycle can be divided into two broad categories:

I. If sintering panel has been used for preheating the furnace prior to charging or after clean and dense scrap has been filled up to the former, then in that case the heat cycle should not be more than 3 hours at 14MW power.

II. If sintering panel has not been used for preheating the furnace, then in that case the heat cycle should not be more than 4 hours 30 minutes at 14MW power.

Preheating the furnace using sintering panel is a RECOMMENDED PROCESS. In extreme conditions, under furnace shift in charge's instructions, furnace can be directly used for heat preparation. But such practices are HIGHLY NOT RECOMMENDED.

2.2.2.1.1.5. Sintering cycle (Sintering panel available for preheating):

After getting clearance from Electrical/Mechanical dept. regarding control supply and pumps, on the LED display panel, the ACI ON and Inverter off message are displayed, and the CONTROL button is switched ON and the system is reset. The HEAT ON button is engaged to start the furnace. All/any discrepancies, regarding the start of the furnace, a message will be displayed on the LED such as Furnace water temperature, Furnace water fail, etc. Post charging of the scrap, the furnace is started on 14MW power.

As soon as required scrap charging is complete and molten metal pool is ready, Sponge Iron (DRI) feeding is started.

Raking off the slag is done through proper tilting of the Furnace. Prior to breakage of carbon, Met Coke in the range of 10/12 Kg/MT shall be added in the bath (%Carbon should not go below 0.10 in the bath). After completion of sponge feeding, residual slag is removed with the help of spoon.

Note: The furnace must be filled up to the SS coil for proper soaking. If not, there are chances of ramming mass getting peeled off.

2.2.2.1.1.6. Regular Process at ET/IT Furnace:

Before preparation of a new heat, thorough checking of the Furnace lining and Tapper Zone, through visual inspection, using black eye glasses, is done and relevant data is registered in furnace log sheet.

Mild Steel Scrap is charged first in the furnace as per planning sheet. For optimum utilization of power, the charge is a blend of heavy scrap like HMS and shredded multi-scrap entity.

As soon as first charging in done in the furnace, CONTROL button is switched ON. The system is reset and the HEAT ON button is engaged for starting the furnace. Under ideal conditions, power pot should be full for optimum utilization of power. But can be adjusted as per shift in charge/melt.

Met-Coke is added initially in bulk along with scrap charging for carbon pick up in the bath. The amount is to be decided by shift in charge depending upon the planning sheet/desired chemistry. Further met-coke is added, stage wise, based on %C opening in the bath and desired chemistry.

As soon as molten metal pool is ready, Sponge Iron (DRI) feeding is started. Raking off the slag is to be done through proper tilting of the Furnace. Prior to breakage of carbon, Met Coke in the range of 10/12 Kg/MT should be added in the bath (%Carbon should not go below 0.10 in the bath). General Operation time should be 3:00 Hours ± 20 Minutes depending upon the charge mix. After completion of sponge feeding, residual slag is raked off with the help of spoon. Slag removal should never be 100% as it will expose the liquid metal to atmosphere, which is not desired when the liquid metal is in furnace.

2.2.2.1.1.7. Alloy Additions:

Following sequence of operation is adopted for addition for both sintering and regular melting process:

After desired removal of slag, the metal temperature is raised up to 1600 ± 10°C and then around 300-400g/MT of Aluminum bar (Al bar) is plunged into the bath. The actual amount is decided depending upon the chemistry required and the amount of liquid metal in the furnace.

After Al plunging, coke and flux (Al mix) are added and stirred well. Under general conditions, addition is in the range of 3-15 Kg. However, the actual quantity is decided depending upon the liquid metal in the furnace.

General Ferro-alloys, which are used for addition in either furnace or ladle, are Ferro-Manganese, Ferro-Silicon and Silico-Manganese. Ferro-alloys (consisting of Silico-Manganese and/or Ferro-Manganese) addition in ladle are not more than 400 Kg under any circumstances.

Rest of the Ferro-alloys is added in furnace depending upon the chemistry required. Ferro-Silicon alloys are also added in the ladle, often. The authority decides the actual quantities of all the Ferro-alloys, which are being used.

Under general conditions, Silico-Manganese addition should be 12 Kg/MT. Before addition of Silico-Manganese in furnace, temperature is raised up to 1640 ± 10°C for better Manganese recovery. After Ferro-alloys addition, liquid metal temperature is checked using temperature lance. The liquid metal is tapped at 1660 ± 10°C. N_2 purging is done at a lower rate (1.5-2 Kg/cm^2 Pressure). Total duration of N_2 purging is a minimum of 3 minutes after tapping to ladle lifting for casting at Continuous Casting Machine.

2.2.2.1.1.8. Key safety procedures to be followed on/near furnace:

- Access to melting and pouring should be limited to authorized personnel only.
- Wearing of helmet and pair of safety shoes is a must for all while on furnace and in the proximity of a furnace.
- Hand gloves are to be used while taking bath sample, ladle sample and temperature of the furnace.
- Light reducing eye, glasses to be worn while visual furnace inspection.
- Heat and flame retardant safety clothing and safety glasses to be worn by workers while using Bari in furnace for any purpose.

2.2.2.1.1.9. Key safety procedures to be followed for running of furnace:

2.2.2.1.1.9.1. Charging

- Only dry charge material should be charged.
- The bundled scrap should be ensured dry before adding to melt.
- Closed or partially closed containers that may contain liquids (beverage cans, sharing tubes, etc.) should not be allowed to mix with furnace charge. Liquids or pieces of combustible material can vaporize instantly upon contacting the melt and scatter molten metal.

2.2.2.1.1.9.2. Molten Metal Splash

When molten metal comes in contact with any water, moisture or liquid bearing material, it instantaneously turns into steam, expanding up to 1600 times its original volume and producing a violent explosion. This occurs without warning and throws molten metal and possibly high temperature solids out of the furnace and puts workers, the furnace itself and nearby plant and equipment at risk. This generally happens by:

- Dropping Wet or damp tools or additives
- Charging Sealed scrap or centrifugally-cast scrap rolls
- Dropping Sealed containers
- Faulty furnace lining along the walls

Primary protection from metal splash and furnace eruptions are:

- Personal protective clothing and equipment

- Scrap drying
- Monitoring Normal Lining wear
- Ground Leak Detection
- Managing Slag or Dross

2.2.2.1.1.9.3. Monitoring Normal Lining Wear

Refractory linings are subjected to normal wear as a result of scraping action metal on the furnace walls. The most intense wear occurs:

- At the slag/metal interface
- Where sidewalls join the floor
- Thin spots caused by poor lining procedures.

The entire furnace is visually inspected after each heat cycle. Special attention to the high wear areas, as described above, is paid and observations are accurately logged.

In situations where visual inspections of coreless furnaces are impossible, for example, when they are used for continuous holding and dispensing, operators should remain alert to the following important warning signs of lining wear:

- Attainments of maximum power at lower than normal applied voltage.
- In a solid-state power supply, when voltage and power starts dropping.
- When frequency is on a higher side
- Useful though they may be, changes in electrical characteristics must never be thought of or used as a substitute for visual inspection of the lining itself.

IT Furnace can go up to a maximum of 330Hz frequency. But general operation after 300Hz is not at all recommended.

2.2.2.1.1.9.4. Ground Leak Detection

Ground leak detector system is crucial to safe melting and holding operations. The system, which includes both a ground detector circuit associated with the power supply and a ground leak detector probe (Antenna), located in the furnace, is designed to provide important protection against electrical shock and warning of metal-to-coil penetration.

At ET furnace, GLD has been set at 2.5A and at IT furnace it has been set at 60mA. Furnaces will automatically trip when GLD value slips beyond this level. Any ongoing operations will immediately be stopped and concerned authorities will be informed. Furnace should not be operated without a fully functional ground leak detection system.

2.2.2.2. PROBLEMS AND SUGGESTIONS:

2.2.2.2.1. CHARGING THE SCRAP AND DRI:

Present:

The scrap charge is being charged with overhead buckets using cranes. The buckets are brought on custom made carriages on tracks from the stockyard to the plant where they are picked up by the overhead crane and inverted over the top-mouthed Induction furnace. The DRI is charged through an inclined metal-guided duct, through a retractable set-up adjacent to each crucible of the furnace.

Issue:

Though DRI charging was effective, the scrap charging is messy and time consuming. The scrap delivered by the overhead bucket spatters the scrap around the mouth of the furnace. Then the crane has to bring an electro-magnet over the messy scrap and put it back into the mouth of the furnace. This method of overhead charging of scrap, forces the DRI to be charged in discrete quantities. The tap time, as a result, is almost 90 min.

Suggestion:

A hopper shaped vessel is to be inserted onto the DRI supply frame so that the scrap is charged into the hopper, which reduces the distress and scatter of charge, thus decreasing after-work and tap time. Metal patterns with packed DRI + Scrap according to the ratio are to be triggered into the furnace in sets of 2-3 per tap.

A suggestion to make the former out of the crap itself is in place. The additional scrap and DRI is packed into the pattern analogous to a matrix where scrap is the holding material and the DRI (pellets + pulverized) fills the gaps.

2.2.2.2.2. SLAG REMOVAL:

Present:

The slag removal is aided by tilting of the vertical axis furnace on a tilt frame.

Issue:

The slag removal is getting difficult, as the viscous slag drags itself slowly from the tap spout and air- hardens, blocking the spout. The tilt of the furnace can be encouraged at the expense of some steel wastage. Manganese recovery is a problem with viscous slag. The temperature gradient across slag thickness is neither constant nor safe for a smooth operation and an optimized production.

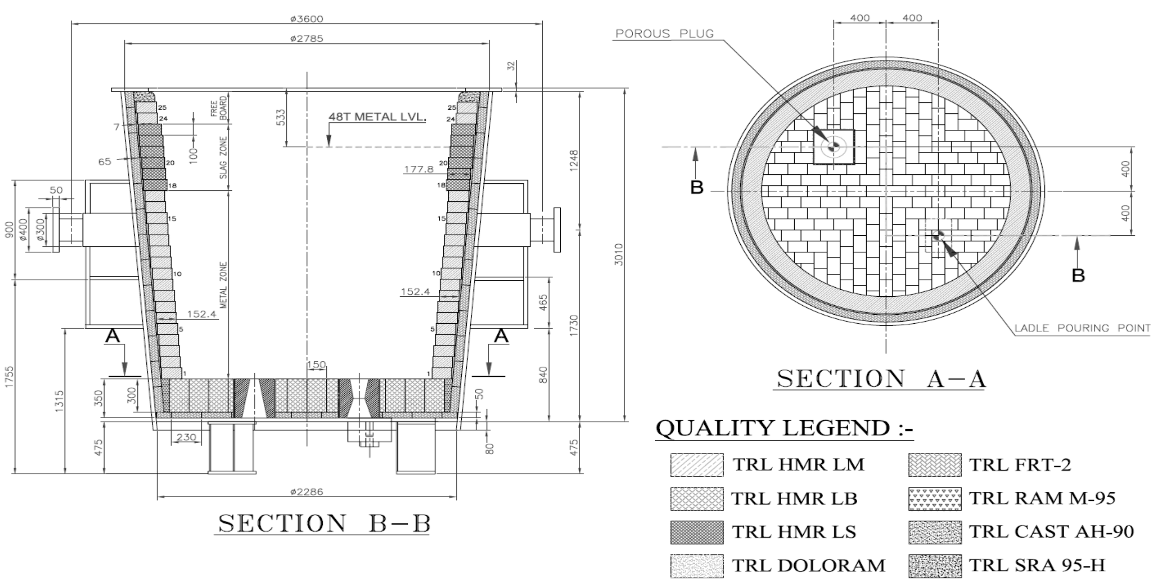
Suggestions:

Slag removal is aided by higher penetrations of the magnetic field. Low frequencies of the IF develop the skin depths and helps in stirring. The slag-metal interface reactions are also aided. Suggestions were given to use grab buckets for the slag removal. Grab buckets are an efficient, low cost and comparatively easier to use than a plunger pushing out the slag off a tilted IF.

The modern trend in the grab bucket technology is the Automated Robotic arm that facilitates removal of slag by backslagging technique. The furnace gets tilted backwards up to 33 degrees, so that sufficient amount of bath is exposed, at which point a robotic arm, inspired by the idea of a grab bucket, slags out the unwanted metal into the slag cart in a very efficient way. The idea has been consideration and the cost sheet is being made. The system plausibly gets into effect by Late 2014.

2.2.3. CASTING OF BILLETS

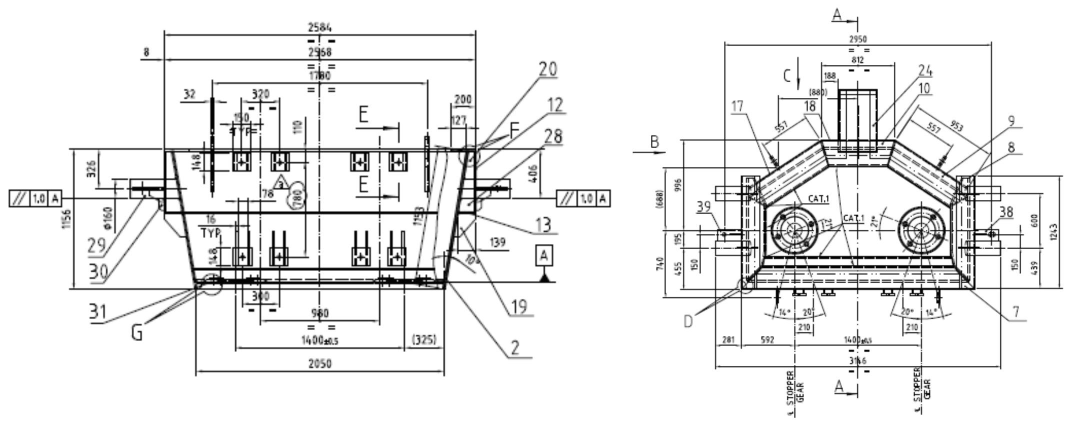
2.2.3.1. LADLE SPECIFICATIONS



A ladle is a vessel used to transport and pour out molten metals. The ladle is essentially a bucket to transfer the molten steel from the Induction furnace to the tundish to facilitate the continuous casting. As shown in the above figure, the U shaped bucket is lined with various refractory bricks and linings to support the high temperature of the molten steel and to contain it in.

Ladles range in size from small hand carried vessels that resemble a kitchen ladle and hold 20 kilograms to large steel mill ladles that hold up to 300 tonnes (330 tons).

2.2.3.2. TUNDISH SPECIFICATIONS



A tundish is a broad, open container, or a reservoir in the top part of a mold into which molten metal is poured, having one or more holes in the bottom. An ingot mold is used so as to avoid splashing and give a smoother flow. The tundish allows a reservoir of metal to feed the ‘SonCast’ continuous casting machine while ladles are switched, thus acting as a buffer of hot metal, as well as smoothing out flow, regulating metal feed to the molds and cleaning the metal.

Metallic remains, called tundish skulls remain inside a tundish and need to be removed, typically by mechanical means, by manual scraping/cutting. Such scrap recovered, is ordinarily reused in the steelmaking process. A casting tundish is lined with refractory bricks, silicon based refractory material, specific to the liquid steel, which is being cast here.

2.2.3.3. THE MOLTEN METAL TRANSFER

The secondary steelmaking starts at about this point in the whole process. The primary objectives of the secondary steelmaking are:

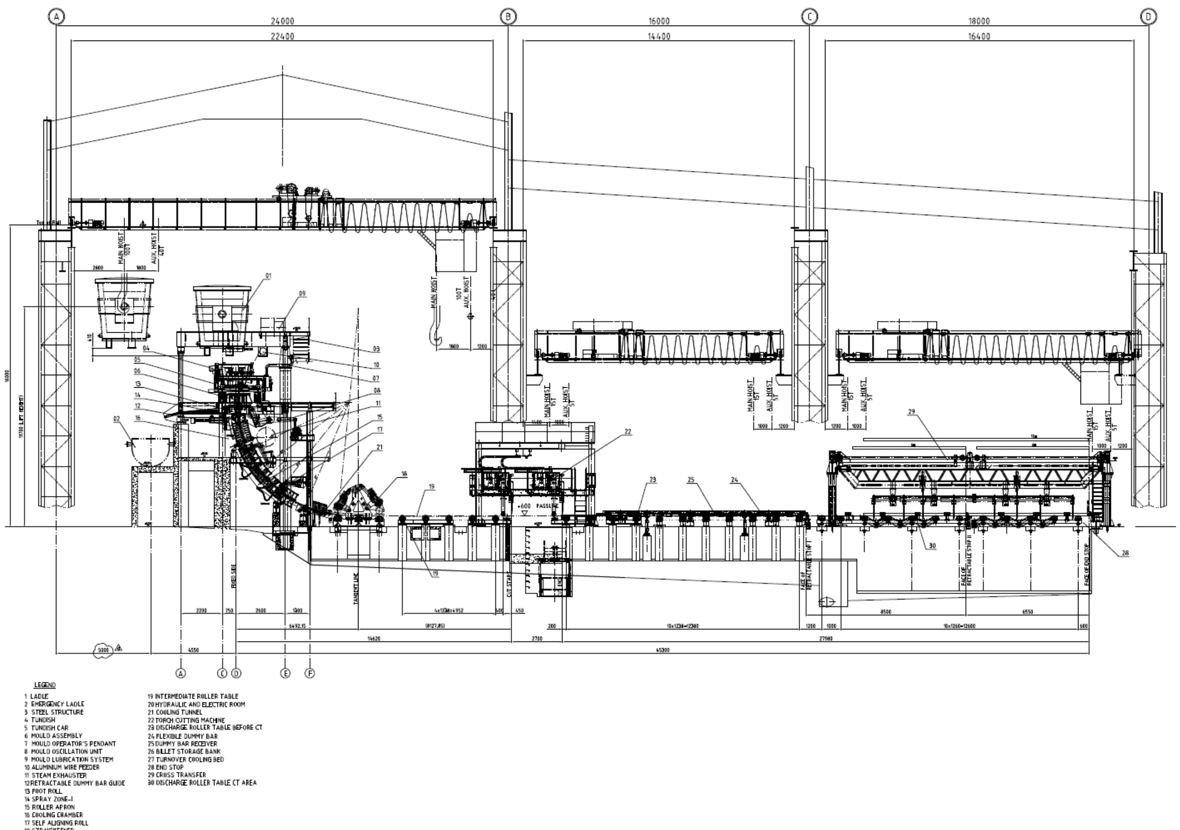
- To stir the molten steel by purging inert gas through the bottom of the ladle.
- To inject slag forming powder either through a lance for further refining
- To produce clean steel either by removing inclusions or modify them by suitable injecting materials
- To carry out de-oxidation and degassing.

In Welspun Steels, de-oxidation, degassing and stirring is done by nitrogen. The ladle is placed in front of the tilting IF by the overhead crane facility post the slag removals. The metal is then poured into the ladle and lifted of for sampling and nitrogen purging.

The ladle is then placed on the tundish, and on the right alignment, the plug gets punctured and the steel starts pouring into the tundish, proceeding to the caster.

2.2.3.4. THE CASTER SPECIFICATIONS

The original continuous casting machines were of vertical types. Now most of the continuous casters have either curved mold or vertical mold with bending rolls.



The caster in Welspun steel is curved, not bent, state-of-the-art equipment with speeds of casting up to 6m/min. But the speeds that are being used are from 1.2m/min to 4m/min just to facilitate the input quantity. The provision of couple of strands facilitates faster rated of production. The metal strands are cut at 3m or 6m based on the customer requirement.

The ladle support is fixed, not flexible. The tundish is a portal type car with rails on the casting platform. The mold design is based on the die section installed, either 100X100 or 125X125 mm. Welspun steel produces square cross-sections of 10X10cm.

The cooling zones are basically, 3 zones, spray ring being the zone 1, zone 2 being the intermediate and zone 3 being the final cooling zone based on air cooling. The first zone is the sprayer (water based), which is entirely section size related.

2.2.3.5. THE CASTING PROCESS

A flexible dummy bar storage unit is stored above the discharge roller table. This dummy bar system is used to set up the caster for casting. The dummy bar is inserted in the reverse way up till the mouth of the caster where it is fused with the molten metal in the tundish. Once the casting is started, the cast rolls forward the dummy bars towards the exit drawing metal attached to it continuously.

The dummy bars are cleaned from scales and any scrapes of metal attached to them and prepared for their next cycle.

2.2.3.5.1. BILLET CUTTING

The withdrawal of the billets is done by CONCAST's withdrawal and straightening unit, which has a quick changing clamp to denote length, which can be pre adjusted for a cast cycle or even for a particular dispatch. Flame cutters cut the billets that are protruded off the caster by expert cutters or welders. The oxygen based flame cutters can be adjusted for depths of penetration and generally are set for 120mm.

The clamp, which stacks the billets for marking and dispatch, has an adjustable clamping force option for avoiding unbending cracks.

All the controllers starting from the billet length controller, the stacker claw and the moving stacker are semi-automatic, programmable logic controllers apt to the section size and support various grades of steel, thus produced.

2.2.3.5.2. THE PRODUCT HANDLING SYSTEM

The product handling system consists of the automatic stacker and the magnetic re-claimer. The stacker system has a claw with multiple grooves facilitating the pickup of the billets. The claw curls in a radius around and under the billet outward strand and picks it up from under, forcing the billet to just fall in the groove. The stacker claw then just places the billets in a moving stacker, which automatically forwards the billets to the stacking area. The magnets then arrange the billets in groups. The billets are allowed to cool and are prepared for marking and dispatch.

The dispatch is by the same stacking magnets acting as re-claimers. The trucks drive in and the magnets arrange the billets in the truck according to the indent sheet.

2.2.3.6. PROBLEMS AND SUGGESTIONS

Ladle Transfer: The ladles are being transported from the IF to Tundish by overhead cranes at about 15 m from the ground, which is very risky. The nitrogen is purged at high speeds for stirring. Many incidents spotlighted serious issues but no serious measures from a technical point of view have been undertaken.

The suggestions by the student were:

- A siren, just not prior to the transfer, but also during and 5-10s after the molten metal transfer from the tilting IF to the Ladle.
- A temporary sheeted wall around the ladle while transferring to avoid accidents or at least provide a reflex time to the workers around.
- Serious safety policy implementations and disciplinary committee.
- Mechanized inert has purging unit installation to prevent sudden eruptions of hot metal avoiding accidents.
- Magnetic guiders of the hot metal that regulate the flow. The technology is very costly, though efficient. Research is still ongoing.

Tundish Transfer: The tundish transfer is done by unplugging the ladle after properly inserting it onto the ladle holder on the tundish platform. Here, the metal spatters a lot and the flow tends to spit out some material onto the sub-level platform. The risk is inevitable for the workers who stand there, at the sub-level tundish platform of the caster; to take sample and force remove the slag and solidified components of the process.
The suggestions by the student were:

- Making the plug-removal process much accurate and calculated to as to facilitate a stream flow of the molten metal to avoid spillage.
- A small walled structure to protect any sudden gush of the molten metal, with a provision to take out a sample.

The Caster: The caster as specified, is state-of-the-art equipment. The only foreseeable problem with it is not using it to its maximum potential of 6m/min.
The suggestions by the student were:

- The produce of the iron ore is not sufficient for the caster to run on its maximum potential. So our initial motif to reduce the tap-to-tap time holds good for the caster too.
- The flame cutters, which cut the continuous strand of metal billet into 3 to 6 meter billets, are manually operated. They can be automated.

The Product Handling: The product stacking and dispatch can be altered with much advanced equipment. But considering the produce and movement of dispatch of Welspun steel, the system works pretty good.
The suggestions by the student were:

- The stacking area is not sufficient for a natural and uniform cooling of the billets. As a result some cool faster than the others, which makes it a problem for the marking team. The area is to be spread.
- The magnetic reclaimers, though work for the company, do a clumsy job. They reclaim the billets for dispatch by magnetically picking them up and placing them at the mark-up place and then, into the truck. Powered hooks can do the job in a more cleaner and efficient way.

3. SELECTIVE OPTIMIZATION: BOTTLENECKING

3.1. THE PHILOSOPHY

The project is done in accordance with a 'present timeline' vs. 'proposed timeline' philosophy to compare the results. The company, being a private sector had some policies regarding sharing the timeline information and this project only sticks to basic figures and theories.

The approach proposed to eradicate or reduce the wastage of the goods, time or service of the manpower, here, in the SMS plant of WELSPUN Steel, Anjar.

A timeline is built using the details of the advancement of the steps in the whole process vs. time. The series, parallel, and overlapping incidents are to be carefully detailed so as to avoid confusion.

Once the timeline is built, several bottlenecks are found in the existing procedure, as explained earlier and suggestions have been thoroughly put forward and discussed.

The procedure that the team, including the Student from NIT Rourkela, has agreed to act upon is bottlenecking of the discrepancies along the timeline of the procedure. As mentioned in the above flow-chart, the experimentation starts with optimizing the scrap input, i.e., increasing the amount of scrap, delivered to the furnace as input, per bucket. This is followed by experimenting with a new method of charging, with the use of 'FORMER', a hollow cylindrical pattern with the inbound dimensions of the Induction furnace, with few mm of thickness to bear the scrap and DRI together, effectively packed. Theoretically, this reduces the number of charges per heat cycle to 60%.

Then the slag zone is experimented; the suggestions are yet in the discussion phase. Some of the suggestions to keep the slag in the molten state rather than viscous state include selective modulation of operating frequency along the length of the furnace, overhead flame using oxy-based burners, etc.

The tap time is to be reduced as the consequent step to complete the optimization. Some of the ideas include, recording a timeline of the entire process including very basic of steps and bottlenecking of the errors or avoidable time-slips.

3.2. THE APPROACH

AIM	TARGETED ZONE

-Increse bulk-density of the charge/input.

Scrap composition:

HMS- high C metal scrap

Pig iron (Jindal Steel, Mandra)

Scrap bundles.

Shredded High Carbon metal scrap

Continuous and discontinuous iron chips

-Reduce number of charges per tap (per heat cycle)

-Decrease charging time

-Maintain slag in molten state by

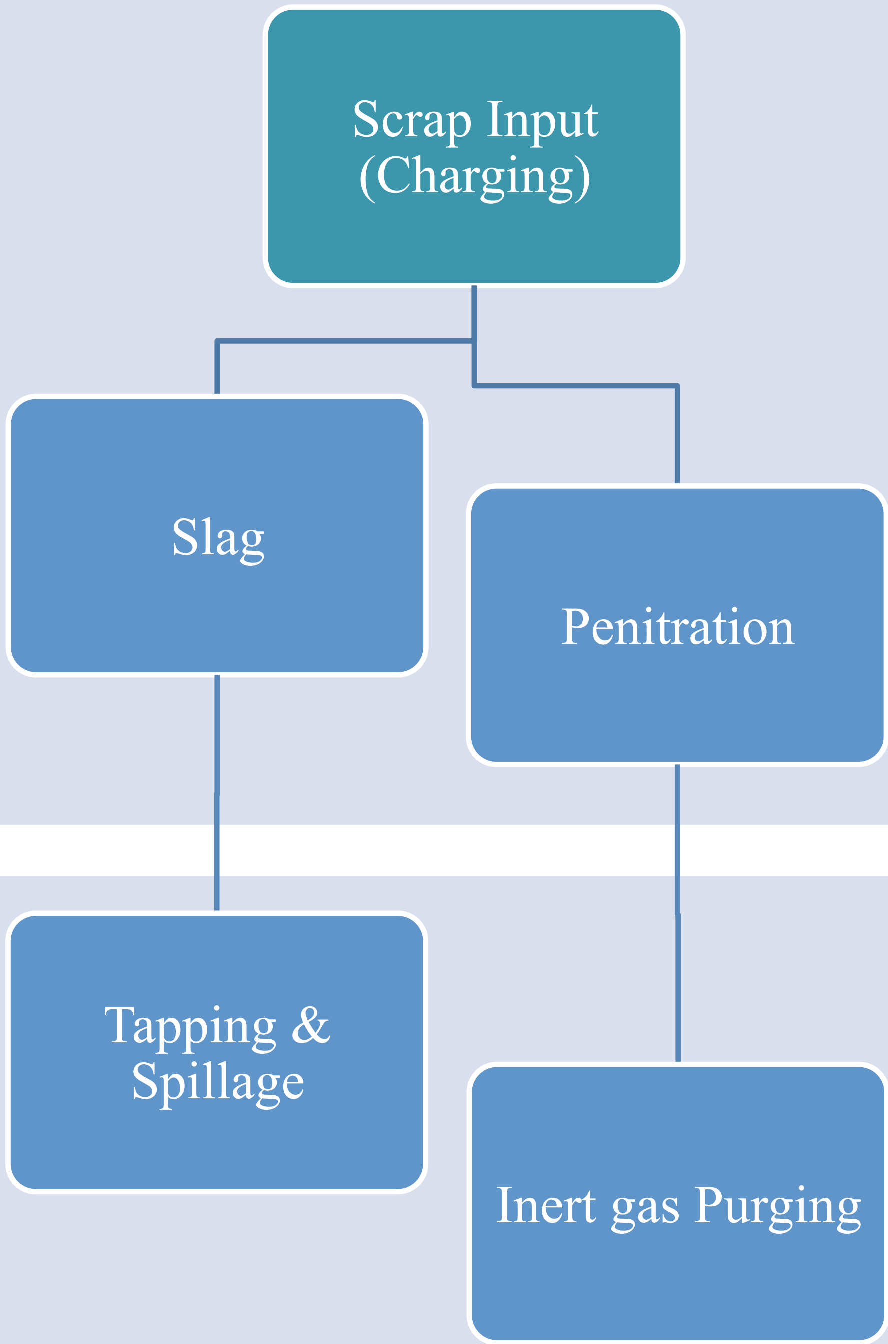
Overhead heating

Low frequencies

-Frequency Modulation for effective penetration.

Low frequency - higher penetration, high skin depth, increased time of heat.

-Maintain slag compostion to assess the output quality.



-Reduce tap-tap time

- Reduce Spilage

(Slag composition as a prime factor)

-Reduce spillage during purging

-Probing new puging techniques

4. MATERIAL AND EXPERIMENTAL WORK

4.1. THE 10kg INDUCTION FURNACE EXPERIMENT

Upon extensive study of the modern trends in the EAF and EIF, an idea to melt the DRI directly without the scrap, to see the effects and side effects, rose to occasion. The team put to the task had the H.oD of the Steel plant (at the time): Mr.Anupam Mittal, an engineer: Idrish Khan, a NITRkl student: Sirish and a lab assistant: Iqbal.

Aim: To see how an IF reacts when charged with only DRI, based on an idea to eliminate scrap usage.

Apparatus: A 10kg IF, a stopwatch, re-bars to remove slag.

Material required: 2 Metal formers made of scrap metal, DRI lumps, DRI fines, Scrap – Metal chips, Scrap – nails and bolts.

Procedure: The preparation for the experiments include gathering of the raw materials required for the experiment, measuring the quantities according to the pre calculated ratios and pre-testing the 10kg IF.

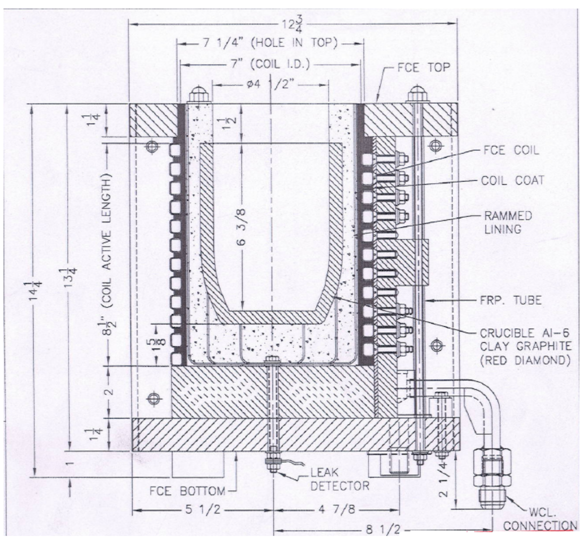


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Fig. 1. Cross sectional drawing of a 10kg Induction Furnace (10Kg). 2. Top view of an actual 10Kg IF. 3. Scrap files. 4.DRI lumps, formers (metal box).

Experiment 1: The Scrap + DRI method.

The dimensions of the former are 98 x 180, diameter X length in mm. The thickness is 2.75mm. Initially, the metal former made of scrap, weighing 1.589kgs is filled with 0.5kgs of Scrap metal chips, 0.656kgs of Scrap nails, bolts and 1kg of DRI fines. The total initial charge comes up to 3.745kgs (~3.8kgs – initial standard).

The furnace was started at 15kw with an initial Scrap to DRI ratio of 64:36. The timings were recorded. After about 17 minutes, the first re-charge of DRI fines (0.5kgs) is added to the metal pool. At about the 22nd minute, scrap metal chips (0.5kgs) and scrap nails and bolts (0.679kgs) were added to the pool.

At about 37th minute, the supervising staff ordered a sample. And the heat was tapped. The point-to-point operations are mentioned in the following table.

Sr. No.	Charging Type	Charging Weight in Kg	Charging Time	Power	Remarks
	Metal bowl	1.589			dia 96x180Lg, 2.75mm Thk, 1.17ltr
	Scrap-Metal Chips	0.500			
	Scrap-Nail+Bolts	0.656			
	DRI - Fines	1.000			
1	Initial Charging	**3.745**	11:31	15kw	Initial Ratio 64% Scrap, 36%Fines
			11:33	20kw	
2	DRI - Fines	0.500	11:48	20kw	
3	DRI - Fines	0.250	11:50	20kw	
4	DRI - Fines	0.250	11:52	20kw	
5	Scrap-Metal Chips	0.500	11:53	20kw	
6	Scrap-Nail+Bolts	0.679	11:54	20kw	
7	DRI - Fines	1.000	11:58	20kw	
8	DRI - Fines	0.500	11:59	20kw	
9	DRI - Fines	0.500	12:02	20kw	
10	DRI - Fines	0.500	12:04	20kw	
11	DRI - Fines	0.500	12:04	20kw	
12	Scrap-Metal Chips	0.500	12:06	20kw	
13	DRI - Fines	0.500	12:08	20kw	Furnace Trip
	Total Charging	**9.924**	**37 Minute**		

Experiment 2: The Scrap former + DRI method.

The dimensions of the former are 98 x 180, diameter X length in mm. The thickness is 2.75mm. Initially, the metal former made of scrap, weighing 1.4kgs is filled with 1.2kgs of DRI lumps and 1.2kgs of DRI fines. The total initial charge comes up to 3.8kgs.

The furnace was started at 18w power, and the stopwatch is started. Different from the ratio of conventional Scrap:DRI::30:70, the ratio being used is Scrap:DRI::36:64. After about 13 minutes, while the furnace was operating at 20kw, the first recharge of DRI lumps (0.8kgs) is added into the former. At this point, the charge already started slagging and a part of it was removed by the re-bars. The molten metal pool was ready to accept the charge.

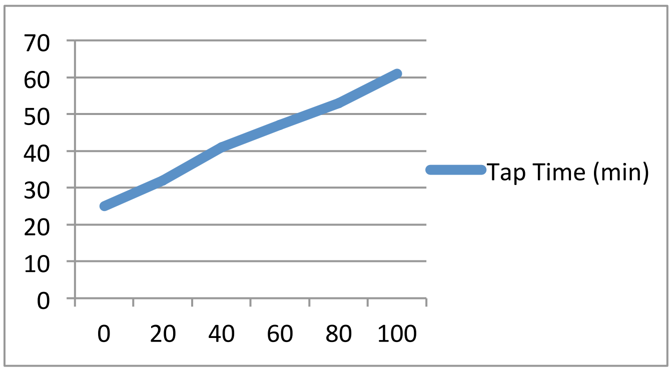
Alternatively, at regular supervised intervals, DRI fines and lumps were added to the metal pool and the timings were registered. At about 50 min, the supervisor ordered a sample to be tested and the result was out to be the steel of required grade. A total of 5kgs of DRI fines and 5kgs of DRI lumps were added in the melt, all through the heat, making the Scrap:DRI ratio of 7:50.

Sr. No.	Charging Type	Charging Weight in Kg	Charging Time	Power	Remarks
	Metal bowl	1.400			dia 96x180Lg, 2.75mm Thk, 1.17ltr
	DRI - Lumps	1.200			
	DRI - Fines	1.200			
1	Initial Charging	**3.800**	11:48	18kw	Initial Ratio 36% Scrap, 32%Fines & 32% Lumps
			11:49	19kw	
			11:50	20kw	
2	DRI - Lumps	0.800	12:01	20kw	
3	DRI - Fines	0.800	12:07	20kw	
4	DRI - Lumps	1.000	12:15	20kw	
5	DRI - Fines	1.000	12:17	20kw	
6	DRI - Lumps	1.000	12:21	20kw	
7	DRI - Fines	1.000	12:26	20kw	
8	DRI - Lumps	1.000	12:28	20kw	
9	DRI - Fines	1.000	12:32	20kw	
			12:38	20kw	Heat Tapped
	Total Charging	**11.400**	**50 Minute**		

Findings: The experiment started with an aim to reduce the use of scrap in the steel production through IF process. The outcome expected was to facilitate the timeline of SMS with lesser number of charges of raw material. Also the experiment is done considering the tap-to-tap time of the heat cycle.

The problem was that, increasing the amount of DRI at the expense of losing Scrap metal, was surely reducing the number of charges of raw material to attain the composition, but also was increasing the tap-to-tap time.

Hence, a series of 14 experiments were proposed with various combinations of DRI and Scrap Former ratios. The results were to be plotted on Y-axis of a graph against the DRI:Scrap. The plots would cross each other, whilst overlapping, to give out a point of optimization according to the break-even analysis.



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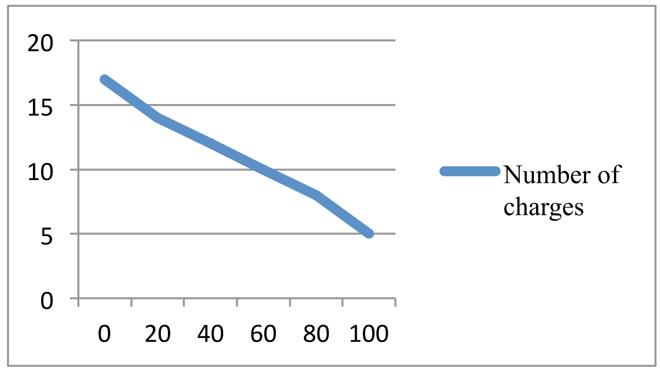

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Fig. 1. The % DRI vs Tap time (min). 2. The % DRI vs. Number of Charges of Raw material.

Drawbacks: The only drawback of this experiment was the oblivious fact of using IF in the first place, to re-use scrap. But production rate was too important for the experimental outcome that this was not taken into consideration.

4.2. THE ROLLING MILL IMPROVISATION

From when the billets are cast, and the batch is dispatched, some billets will be forwarded to the rolling mill for the TMT re-bar production. As explained earlier, the Rolling mill is a cross-country mill, basing its production on naively automatic equipment. The strands are to be adjusted for every set-up, i.e., every batch. The re-heat of the billets is done by a coal-based-gasifier, which is not economical for the productions, which Welspun is presently handling. The roll passes; both primary and intermediate have several curled strands, are not well equipped with spaces required for the rolling. Welspun placed the students of NITRkl on the team that was undertaking the renovation project.

Secondly, the billets from the gasifier are manually dragged out into the initial roll pass and manually lifted from the first pass and is to be precisely placed in between the rolls of the second. This is being done by a lever mechanism, which is a two man operated mechanical contraption, facilitating the job.

The problems with this arrangement were

- The time lapse: Every billet is being stopped before the previous billet is passed through the first roll pass and is carefully inserted in the second roll pass, which is basically vertically collinear to the rolls of the first pass.
- Highly dangerous: The rolls throw the billet after the first roll pass at high speeds to facilitate the volume consistency. Handling a hot billet at high speeds in a limited space manually is too difficult and hazardous.

Initially the students gave an idea of a tilting bed, as a first step of a suggestion, which acts, on a similar mechanism as that of the lever previously displayed. The suggestions were made to facilitate a mobile fulcrum, to compensate the space crisis. But the model was too complicated, not to mention it's basic modality. The student has given the idea of an industrial robotic arm, which suits the requirements. The idea is being worked out and will be implemented in late 2014.

5. RESLUTS AND DISCUSSIONS

On summarizing the drawbacks, lots of suggestions were given as a part of the project. But, the company being basically a profit-based firm had its own restrictions in bringing out the data outside the firm. The experimentation started but was not scheduled through a stipulated time frame. The projects started were postponed to such a time as and when the students join the firm. Last in the end of the list is the fact that the project was, hence, theoretical.

Summarizing the results, the students offered the following:

- Suggestions regarding the cleanliness of the DRI plant, to install automated suctions in vital areas in the field like the magnetic separators of the pellets.
- Suggestions regarding stronger and safer work ethics, including a better induction of the Health and Safety department of Welspun Steel.
- A study of a comparative study of NG vs. C based DRI.
- Suggestions regarding the transport systems of the raw material onto the IF platforms or into the furnace, to enhance the hopper system that stores the DRI before charging and the segregation systems of scrap in scrap yard.
- Suggestions regarding the charging of the raw material, involving a former made of scrap of 30% and the rest being DRI. This idea is being extensively studied and soon a breakthrough is expected.
- Suggestions to add vibratory legs to the DRI charging retractor frames to ease the flow, adding an advantage to the gravity.
- A stretch of 14 experimentations leading to a break-even optimization between tap time and number of charges, of which the first two are discussed above and the rest are presumably done in August 2014, and to be forwarded for the approval of a trial run as per agreement.
- A requisition for slag analysis and the interface reactions, to understand the slag removal problem, which did not see much light due to the absence of concerned officials.
- Suggestions to slag removal problems, to incorporate backslagging along with the automated robotic arm, to facilitate the limited removal of slag, for the reactions of alloy recovery to not to get affected.
- Suggestions to invest in temp-metal walls to avoid spatter and accidents while the tilted transfer of hot metal from IF into Ladles.
- Suggestions to invest in plug cutters for the ladle, to facilitate the smooth and streamlined pour into the tundish, avoiding spatter.
- Suggestions for the automated cutters, instead of the manual workers, to eliminate labor costs, errors and clutter, and enhance the interdependence of productivity and automation.
- Suggestions to improve the stocking space for easy marking, cooling and dispatch of the billets post production.
- Suggestions to invest in a robotic arm instead of a manual lever to switch the elongating billets in the rolling mill, considering the volumetric consistence and the heat and the vibration, which is harmful when handled manually.

- Suggestions to automate the plant, which was not encouraged, as a plan of semi-manual up gradation was already in play.
- Suggestions of tilt beds and levers to facilitate smooth transition between the primary, intermediate and secondary roll passes in the rolling mill.
- Suggestions of Hydrophobic and Oleo phobic coatings to be applied onto the machinery to prevent them from the frequent rusting and regular maintenance.

6. CONCLUSIONS

As the part of Welspun fellowship scheme, the students was not only able to freely suggest and experiment with the equipment and proceeding but was also given the opportunity and freedom to understand the management of the Plant. Though, the company is a competitive business oriented organization, which is why the level of information about it is at its minimum, the officials were enthusiastic enough to welcome the students to the company. The one-year was not just a project experience but was also a mini-training period, which made the students realize the actual work that needs to be done to complete a project, when dealing with an MNC.

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